New MuCh geometry (v23b) for di-muon simulations

Pawan Sharma,
VECC Kolkata,
23 Oct, 2025

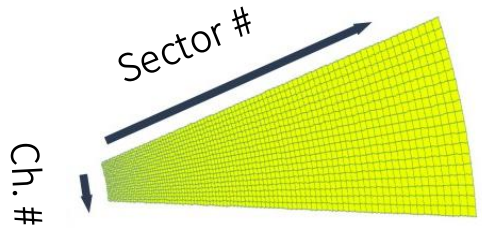
MuCh geometry

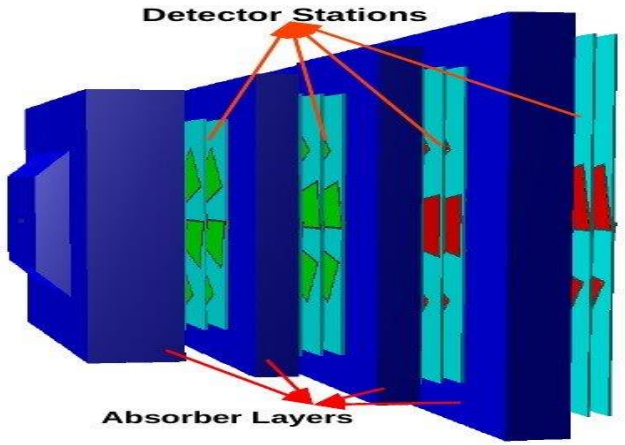
- No of Stations : 4
- No of layers/station : 3
- Shape of Each module: Trapezoidal

No of modules in each layer :

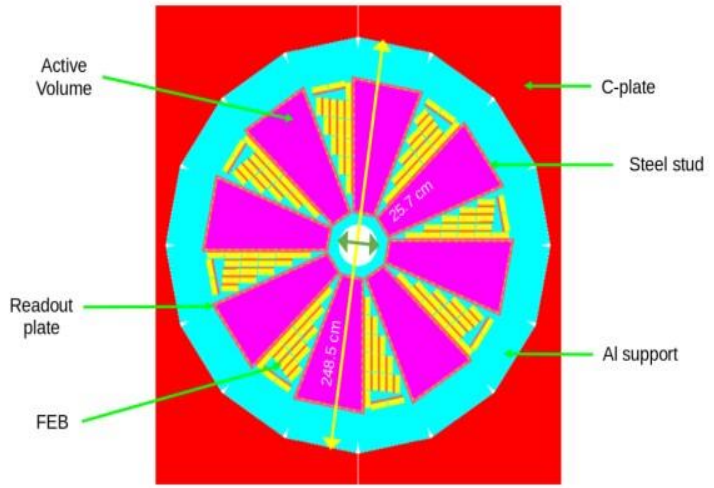
- Station 1 : 16
- Station 2 : 20
- Station 3 : 18
- Station 4 : 18

Readout plane : Segmented into progressively increasing pads.





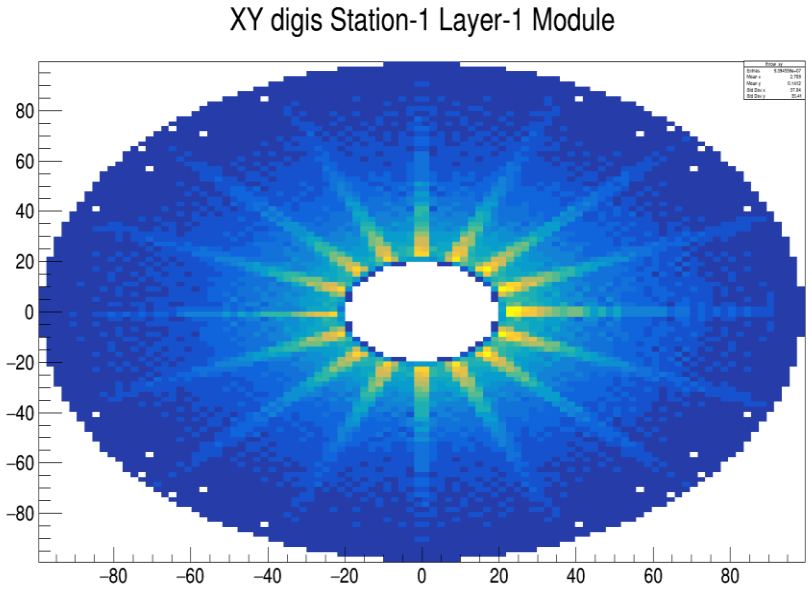
MuCh setup



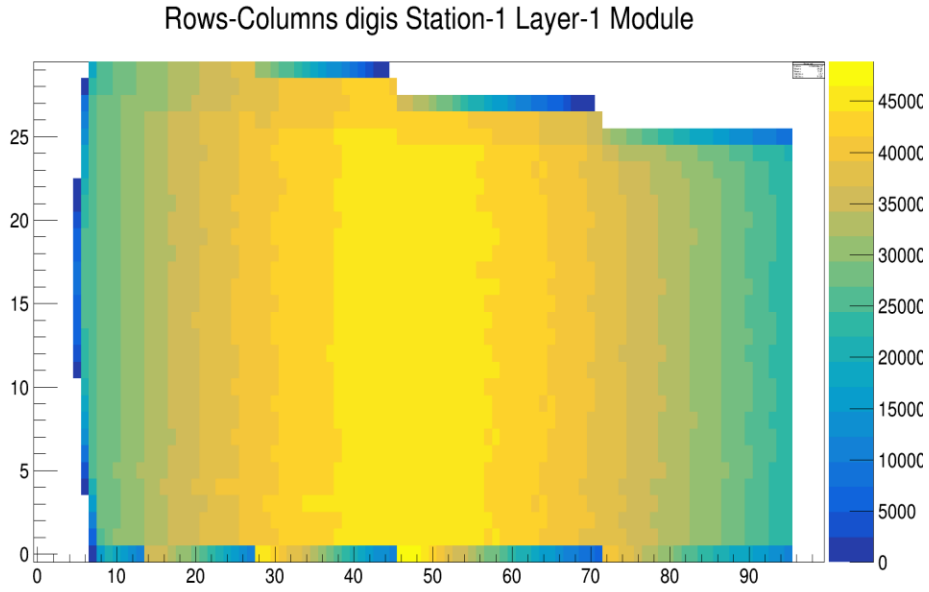
MuCh layer

Issue with v21c (CFV) geometry

- The MuCh geometry, tagged v21c was used as default geometry for muon simulations but there were some issues regarding digitization in the geometry. So, a new MuCh geometry was created tagged v23a for more realistic simulations.



XY distribution of digis



Sector-channel distribution of digis

v23a geometry

- Realistic material budget such as Steel pillars, inner spacers and edge frames in GEM modules and FEBs, C-plate etc have been added.
- Transport time for v23a geometry is ~6 times more of v21c geometry, for 8AGeV AuAu mBias collisions. The reason could be extra material budget and complex components in v23a geometry.

8AGeV AuAu mBias collision(50 events)

S.No.	Geometry Component in v23a	Transport time (sec)
1.	Drift extension	3
2.	Al support	107
3.	FEB support	5
4.	Steel support	31
5.	Edge frame	1
6.	C-Plate	7

To reduce the computational time, changes have been done in some components of v23a geometry.

Comparision of MuCh geometries

v23a
(rejected)
Transport time/event: 8s

- Active volume
- GEM Foil
- Drift
- Gas
- Al Support (slotted)

- inner spacers
- edge frame
- FEBs
- Steel support
- drift extension
- C-plate

v23b
(proposed/optimized)
2.3s

- Active volume
- GEM Foil
- Drift
- Gas
- Al support (unslotted)

Simplified:

- inner spacers
- edge frame
- FEBs
- Steel support
- drift extension

v21c
(default)
1.4s

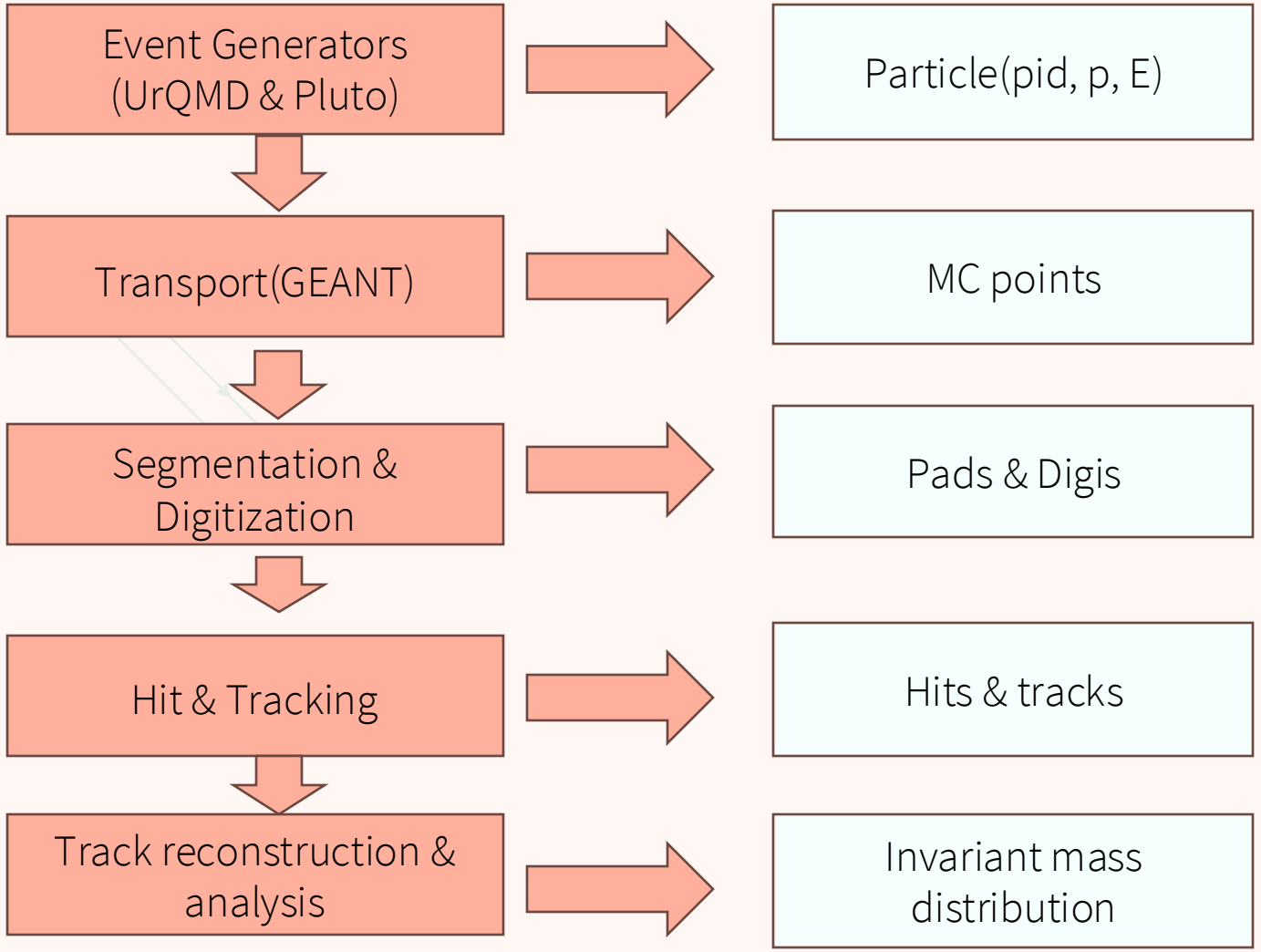
- Active volume
- GEM Foil
- Drift
- Gas
- Al support (unslotted)

Muon Simulations

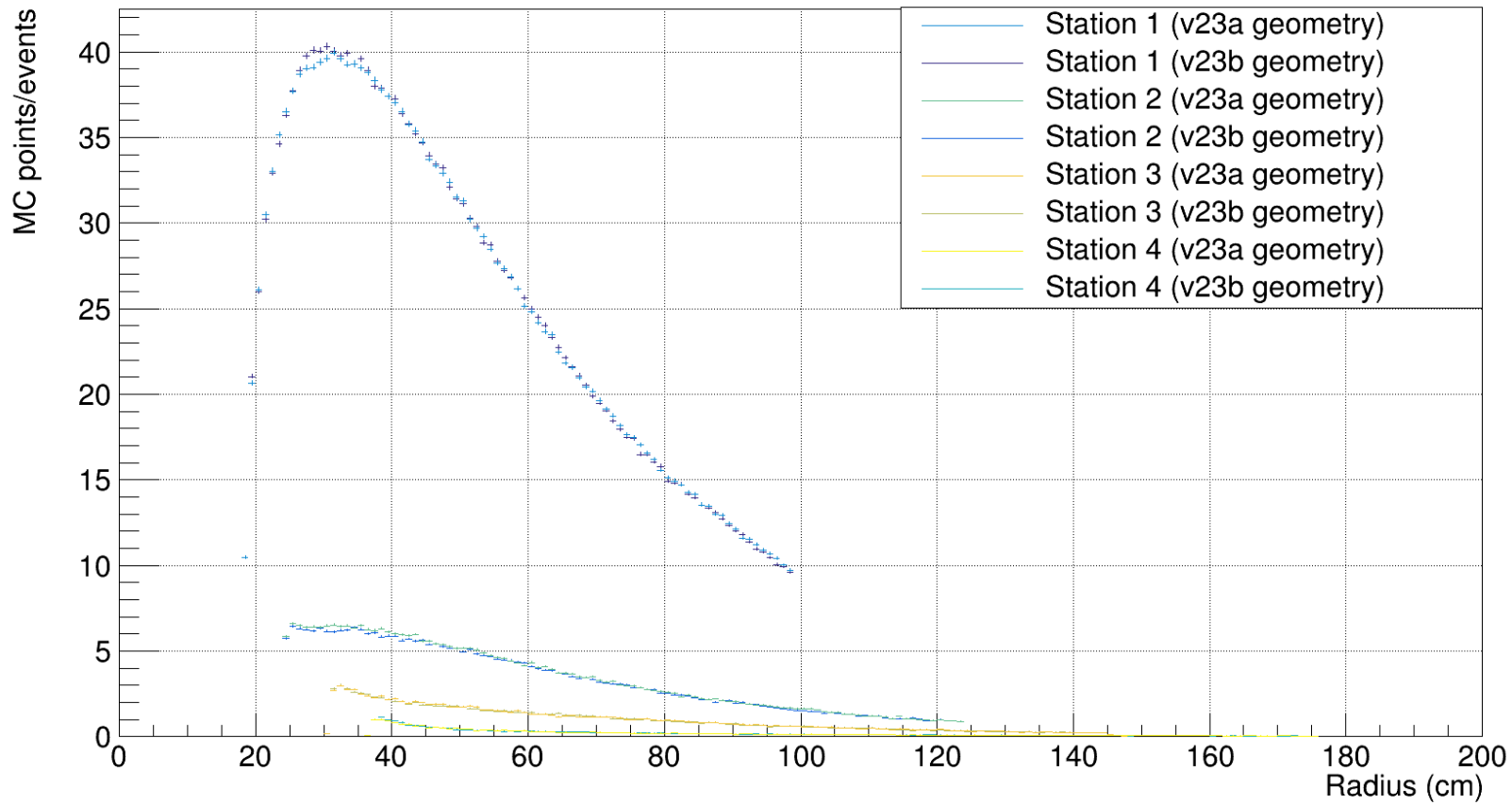
Basic Simulation Info

- **MuCh Geometry** : v23a/v23b
- **Event Generator** : URQMD & Pluto
- **Beam & Target system** : AuAu
- **Energy** : 8 AGeV
- **Centrality** : central
- **Setup** : SIS100
- **No of Events**: 100k

Track reconstruction



Simulation:
Radial distribution of MC points

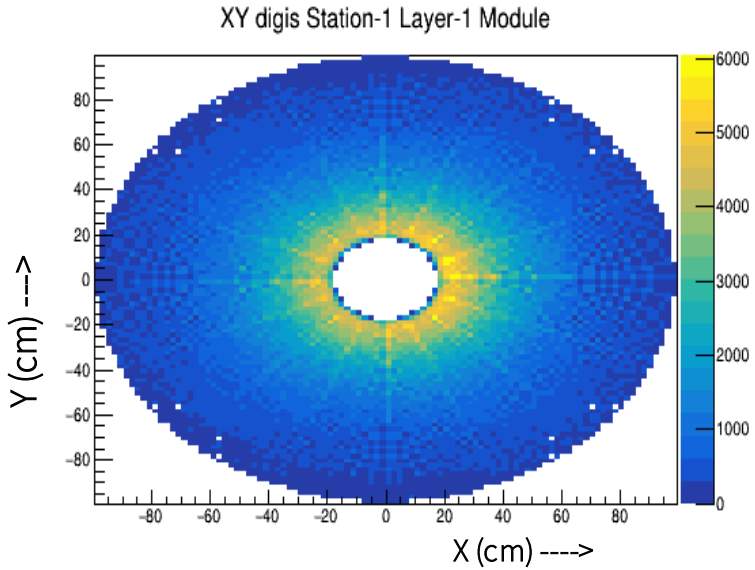


8 AGeV AuAu
central collision

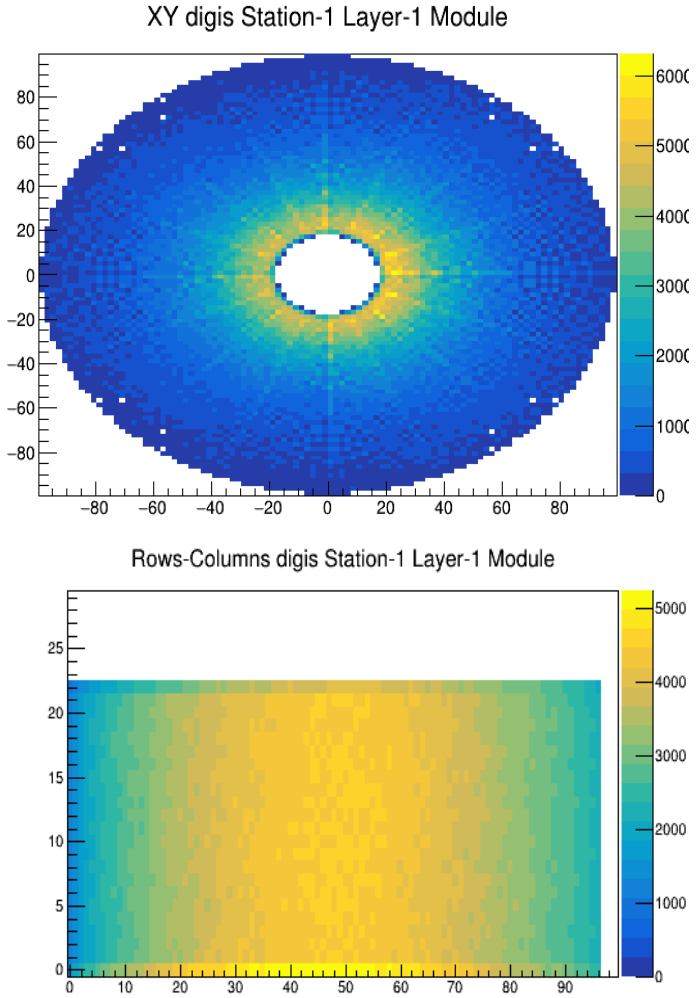
XY and sector-channel distribution of the MuCh digis

8 AGeV AuAu central collision

v23a

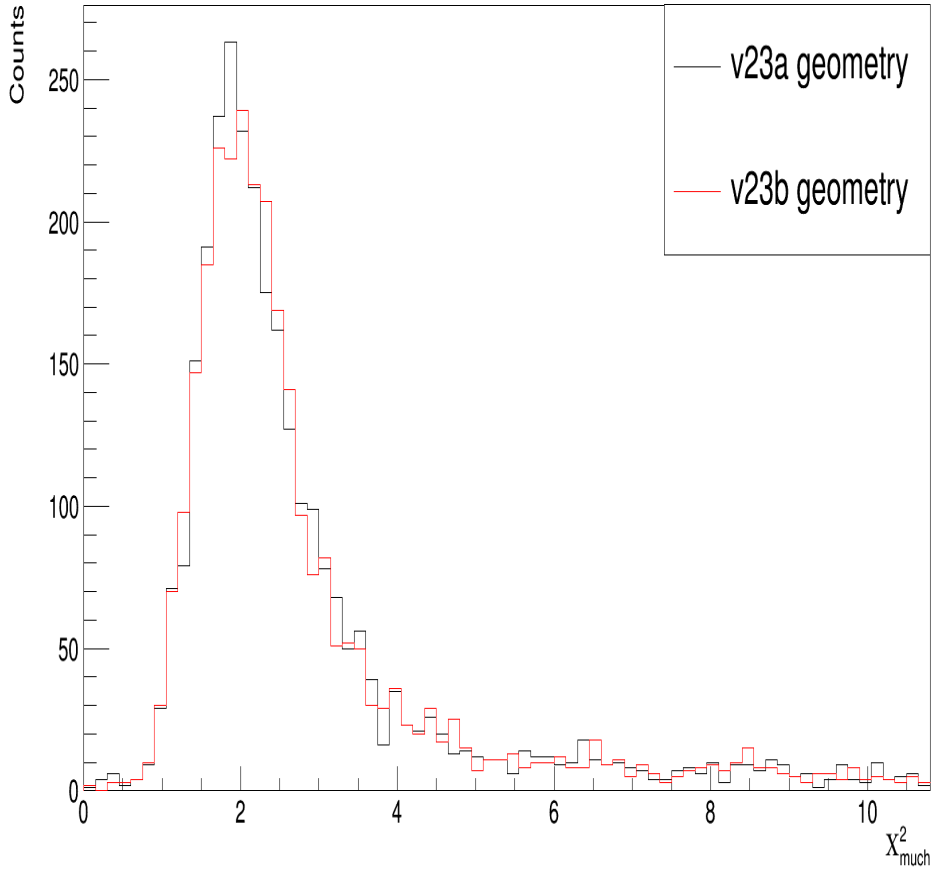


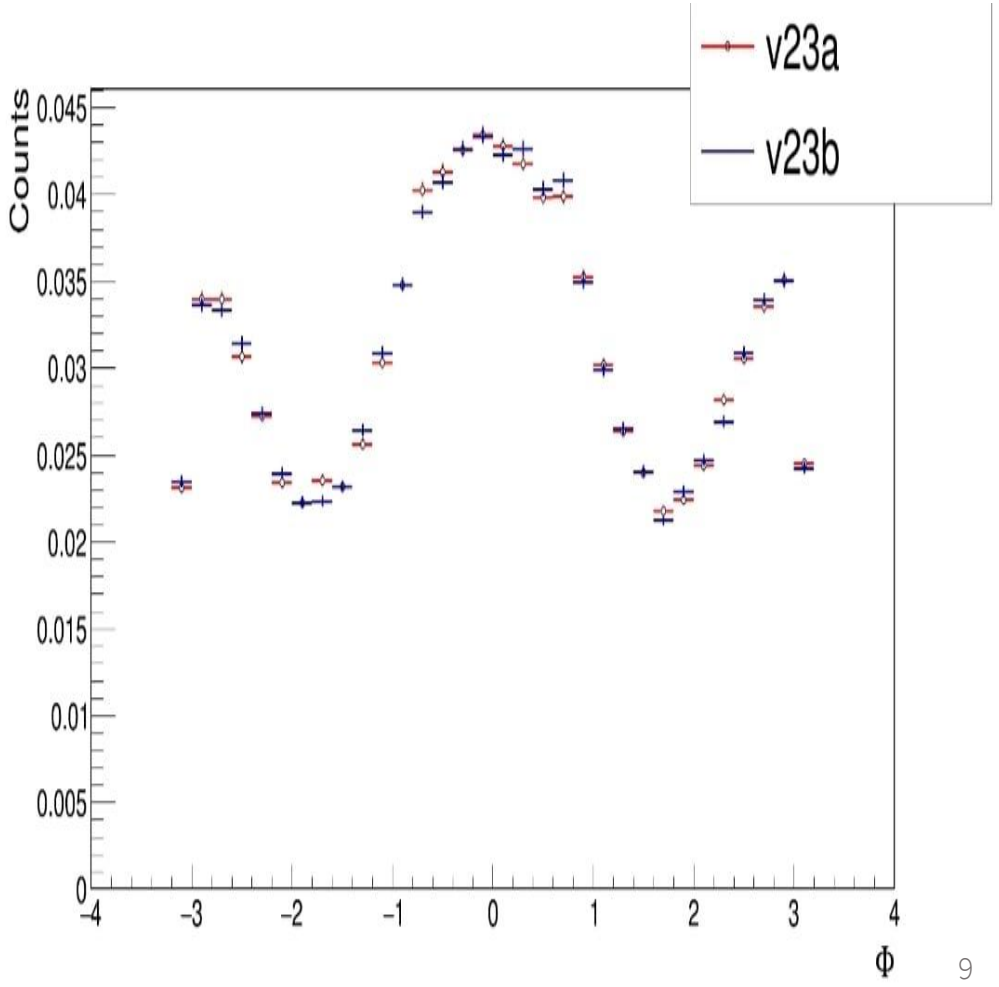
v23b



MuCh Chi2 and azimuthal angle of reconstructed tracks

8AGeV AuAu central collision

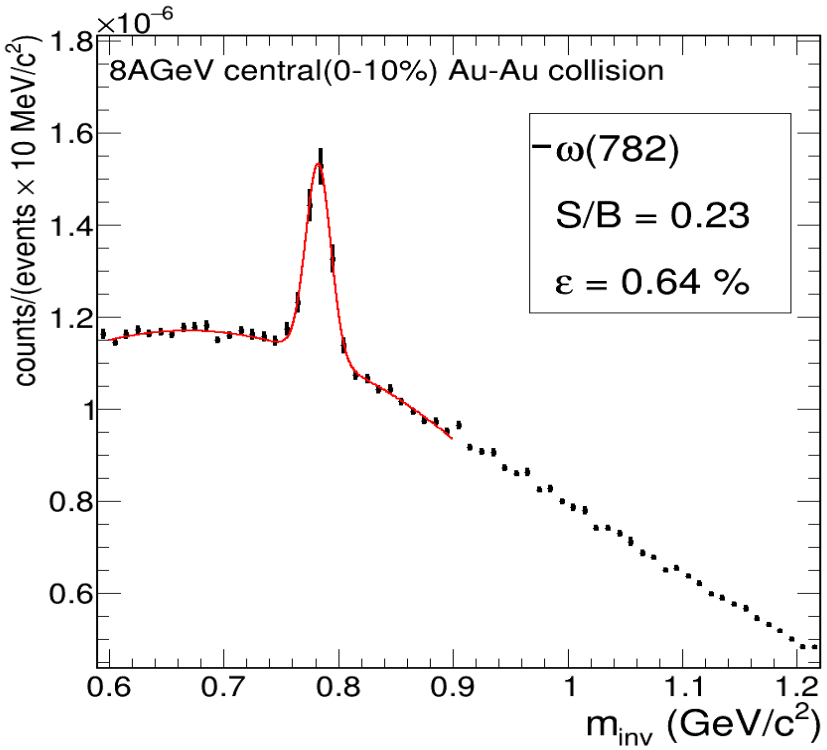




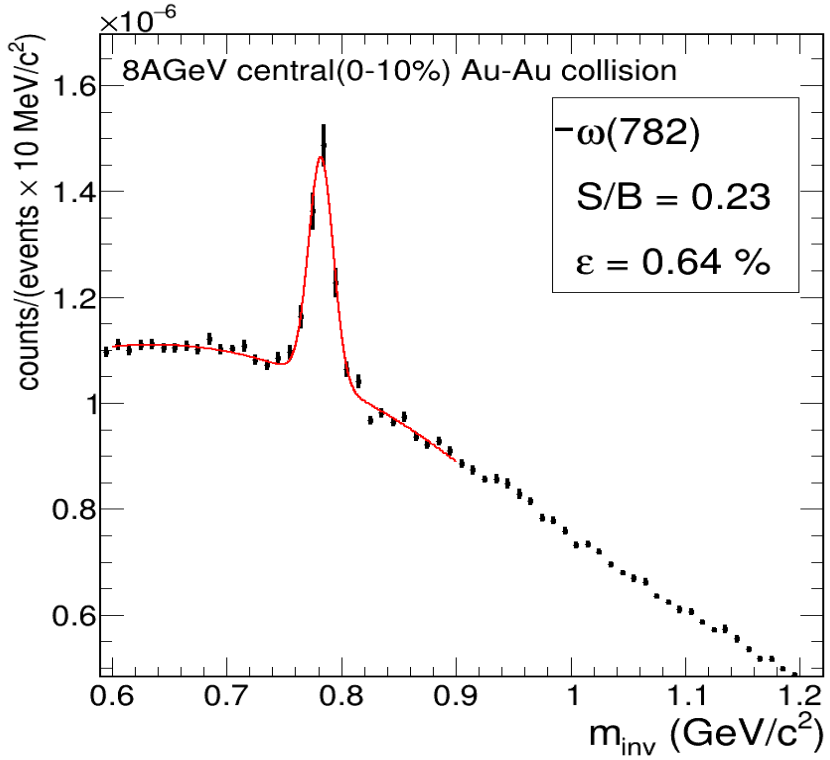
Invariant mass spectra of omega meson

8AGeV AuAu central collision *

v23a



v23b



- Following selection cuts were used: Number of MuCh hits > 11, Number of STS hits > 7, Number of TRD hits > 1,Number of TOF hits > 1, $\chi^2_{MuCh} < 3$, $\chi^2_{STS} < 2$, $\chi^2_{vertex} < 3$, SigmaToFCut=2
- Similar S/B ratio and reconstructed efficiency for v23a and v23b geometry.

*scaling factor with HSD

Summary

- Elements consuming large time simplified and significant reduction in time was observed.

- Transport time for v23b geometry which is equivalent to v23a material budget, transport time reduced from 8s/e to 2.3s/e (which is1.6 times of v21c) for 8AGeV AuAu mBias collision.

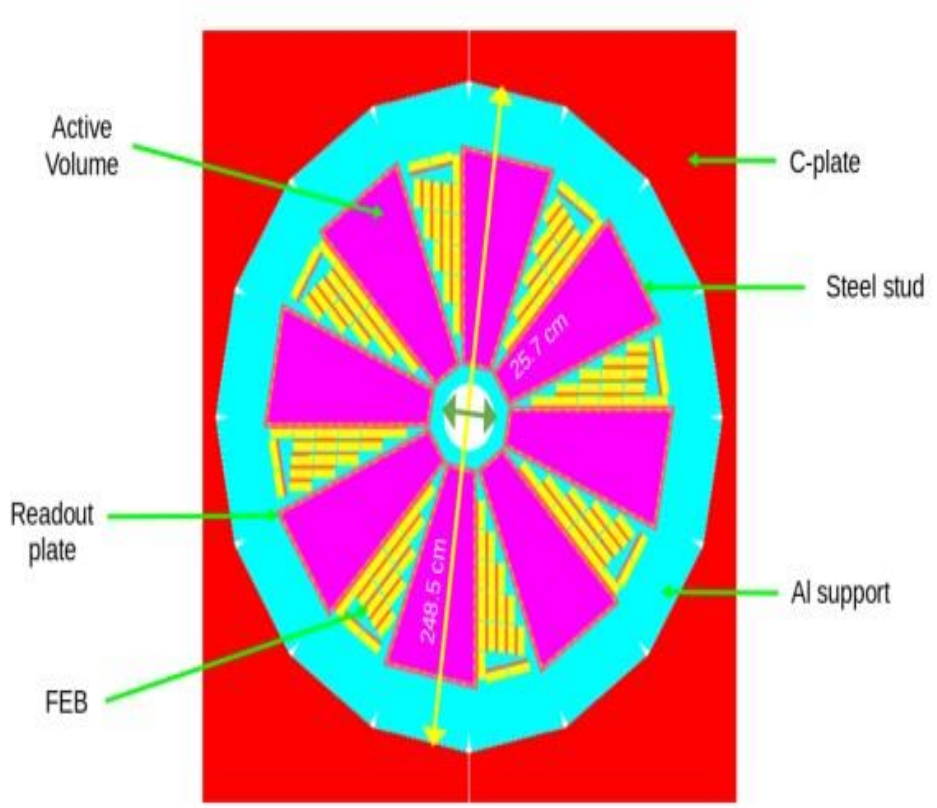
- Simulation results of physics studies of both geometries are comparable, so v23b geometry is proposed as default geometry for the MuCh simulations.

Geometry	Reconstructed efficiency(%)	S/B ratio
v23a	0.64	0.23
v23b	0.64	0.23


Thank you

v23a geometry

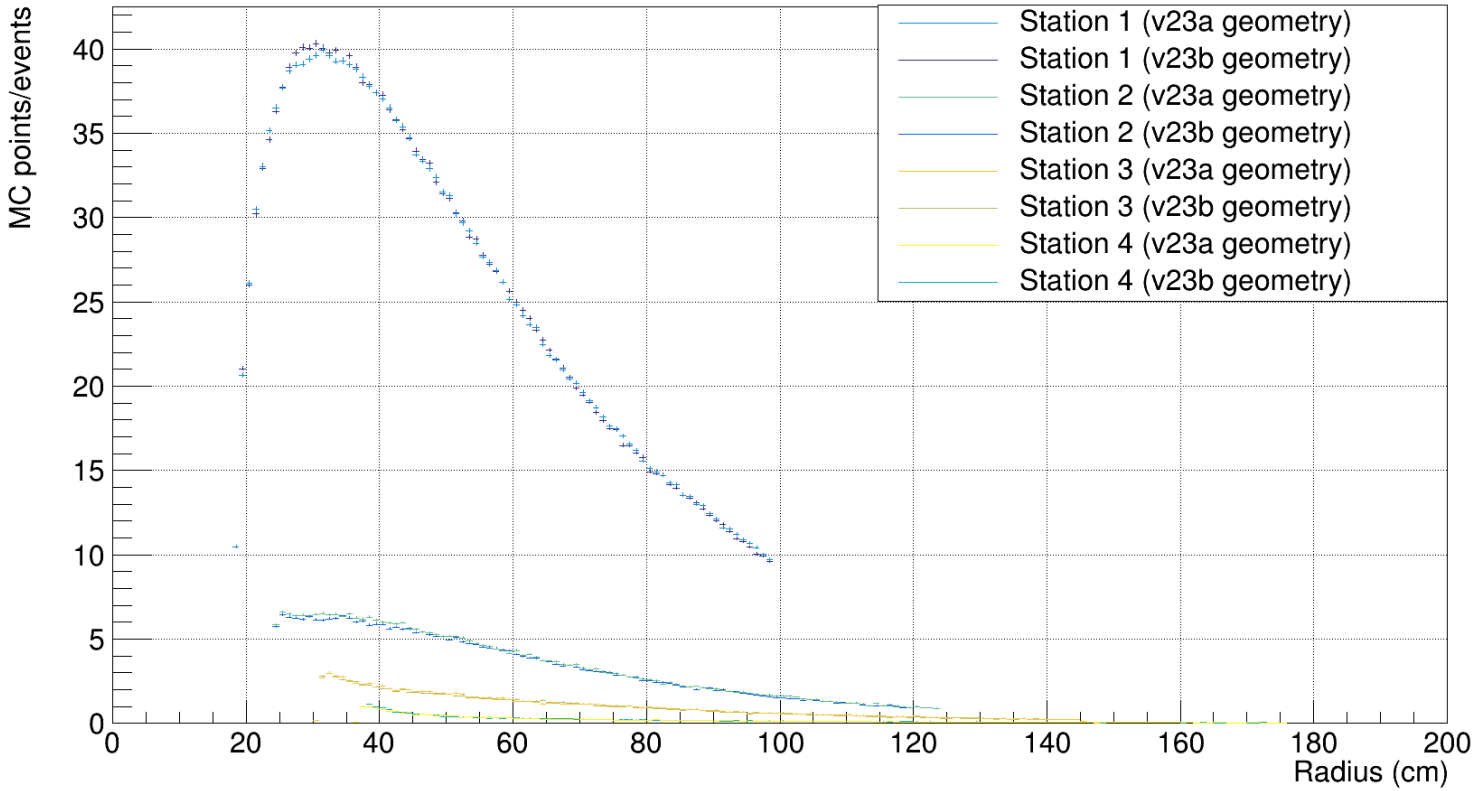
- Steel support, inner spacers and edge frames have been added in GEM modules.
- 18 FEBs have been added over the cooling and support plate. Additional copper plate has been introduced with the PCB which will be used to couple the cooling with PCB.
- C-Plate have been implemented. It is used to mount cooling plates to the overhead support.
- Dimensions of PCBs have been fixed and correctly implemented. An extension of PCB board to hold optocoupler based electronics is introduced.



MuCh layer

Simulation:
Radial distribution of MC points

8 AGeV AuAu central collision



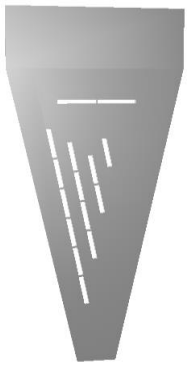
MuCh geometry components

v23a

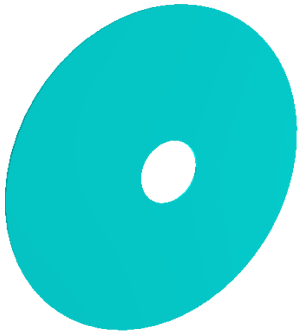
v23b

Al Support

slotted



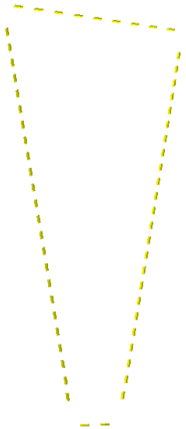
For a module



For a layer

Steel Support

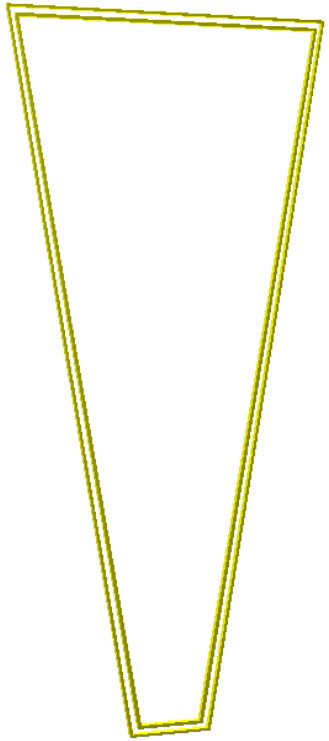
9mm steel pillars
2 mm central cutout
2 mm strip cutout
(3 nodes)



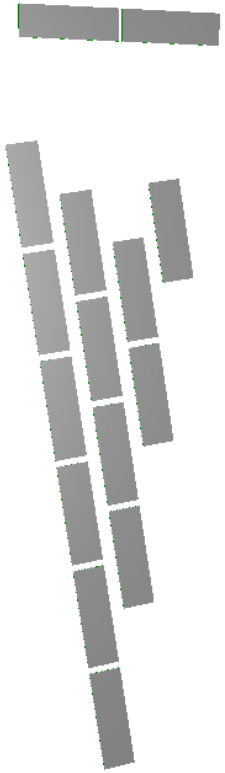
9mm steel pillars
(1 node)

simplified

MuCh geometry components



Edge frame

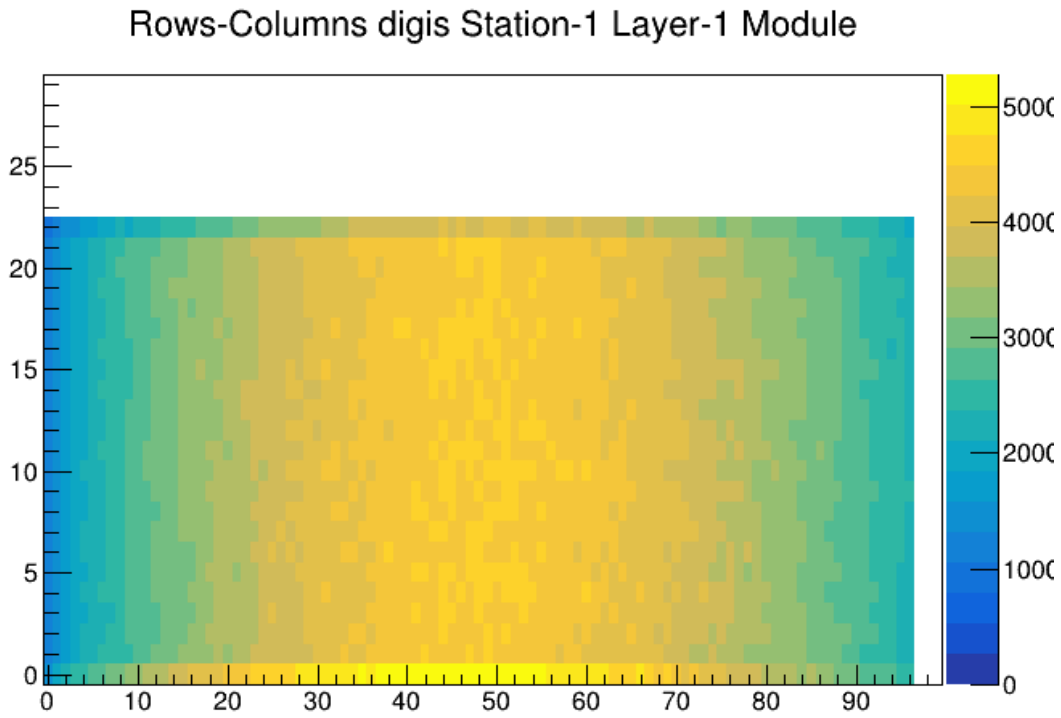


FEB support layer

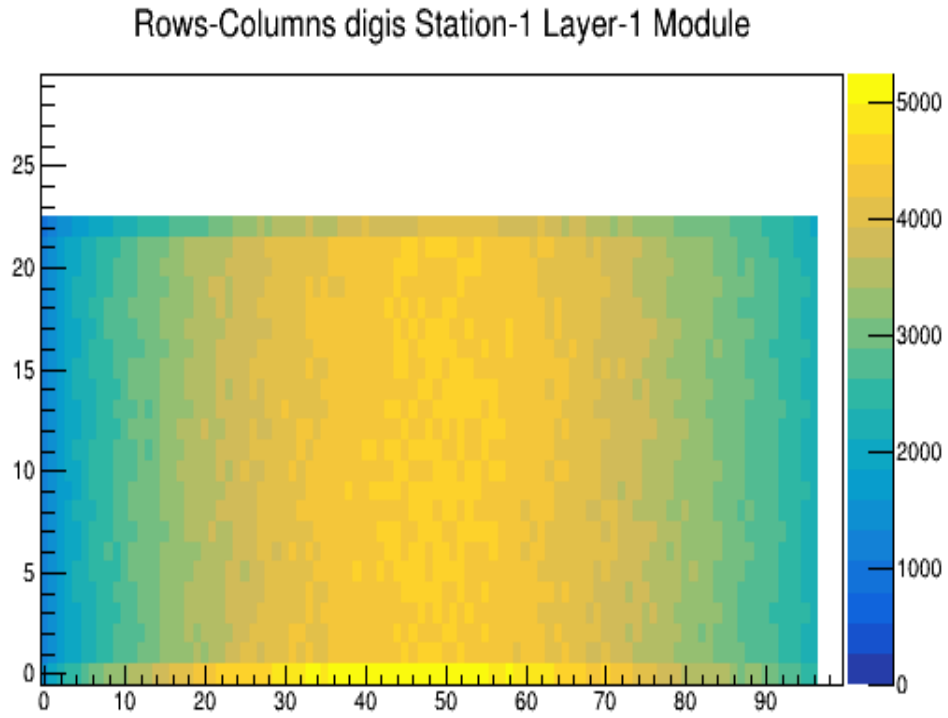
Drift extension

Sector-Channel distribution of the much digis

v23a



v23b

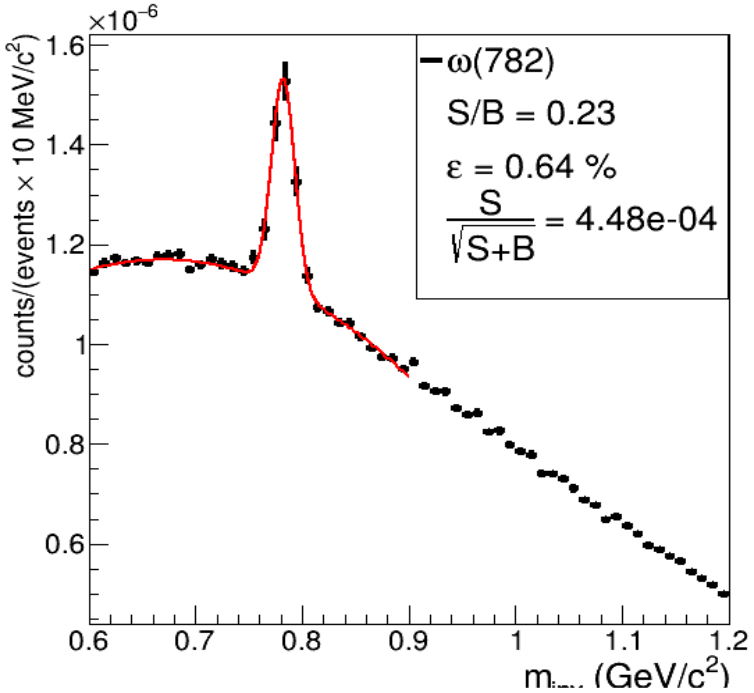


- 8 AGeV AuAu central collision (10k events)

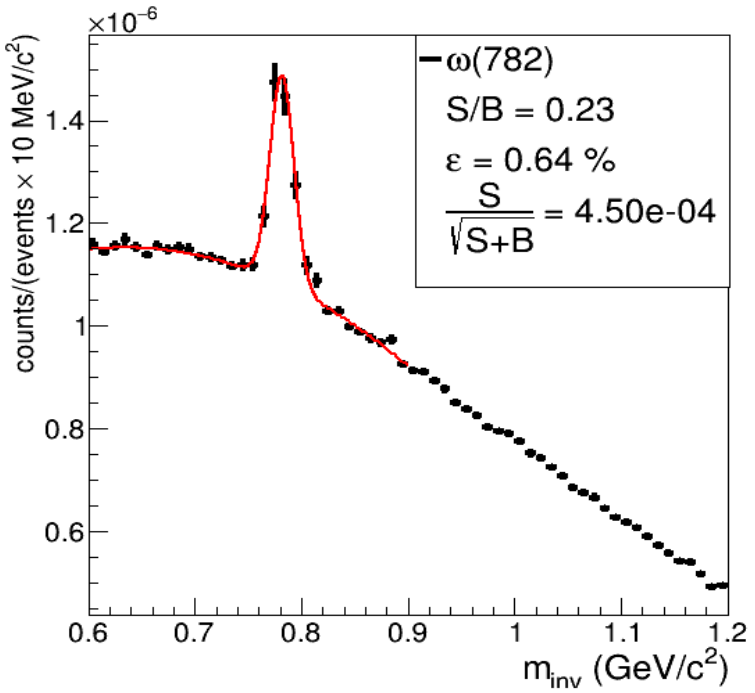
Invariant mass spectra of omega meson

8AGeV AuAu central collision *

v23a



v23b

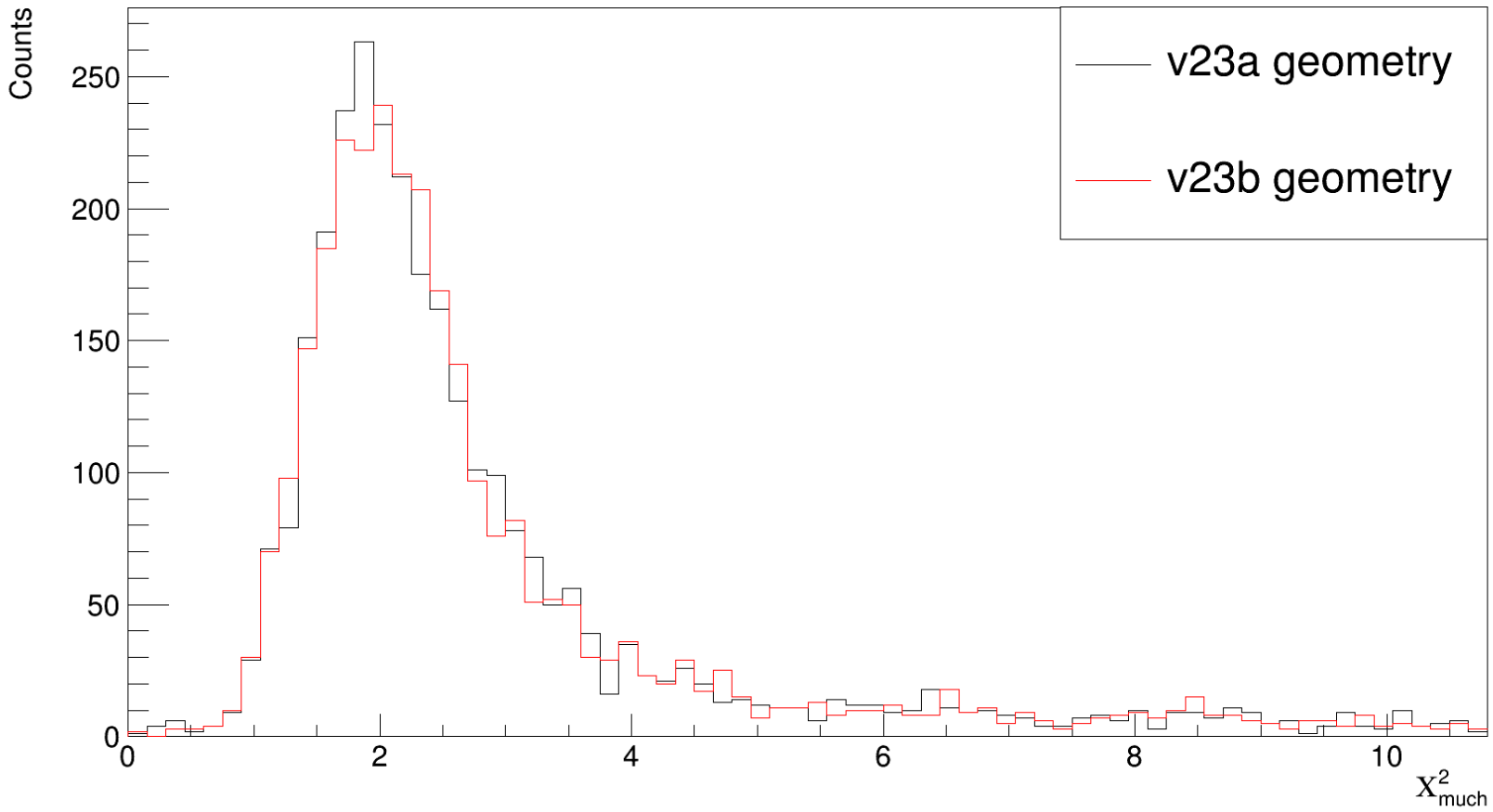


- Following selection cuts were used: Number of MuCh hits > 11, Number of STS hits > 7, Number of TRD hits > 1,Number of TOF hits > 1, $\chi^2_{MuCh} < 3$, $\chi^2_{STS} < 2$, $\chi^2_{vertex} < 3$, SigmaToFCut=2
- Similar S/B ratio and reconstructed efficiency for v23a and v23b geometry.

*scaling factor with HSD

MuCh Chi2

8AGeV AuAu central collision



New MuCh geometry v23b for SIS100 lmvm setup

-> Investigation towards identifying detector layout with optimized material budget and computational time

-> Comparision of transport time for the geometry v23b with v23a and v21c for 8AGeV AuAu collisions

Muon Chamber (MuCh) at CBM

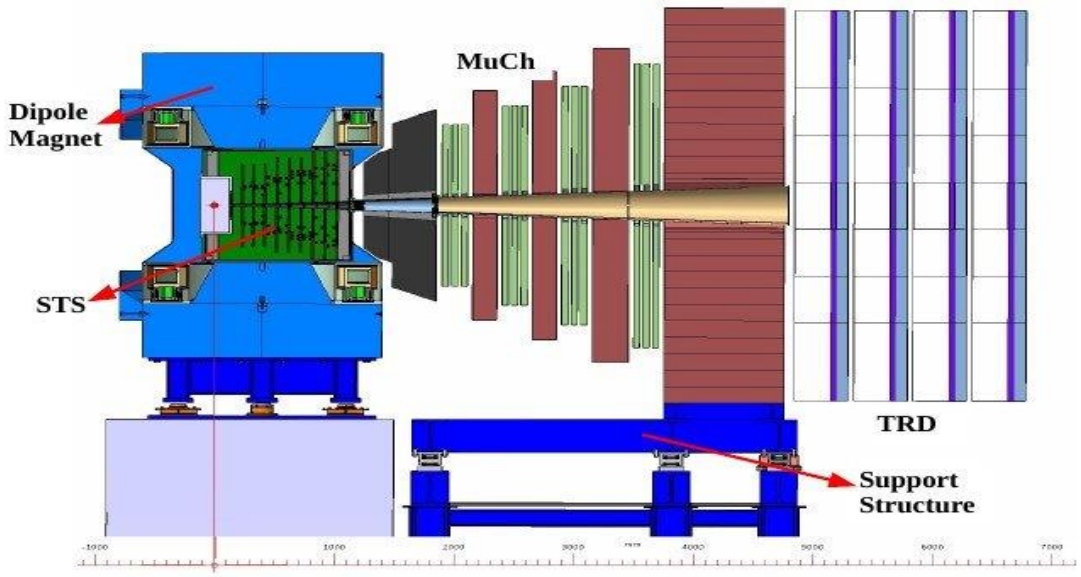
Aim is to measure dimuon
=> LMVM and
=> Charmonia → $\mu^+\mu^-$

-> Originating from ρ, ω, ϕ etc

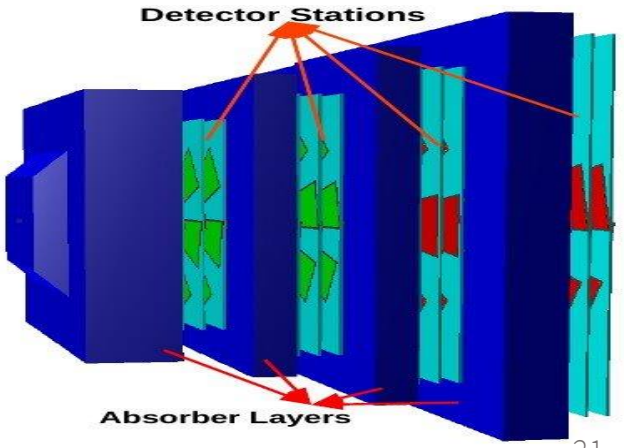
Angular Coverage~5° to 25°

Optimized Absorber Thickness:
58 cm graphite & cement + 20 cm Fe + 20 cm Fe + 30 cm Fe

->Segmented absorber allow us to reconstruct low momentum muon

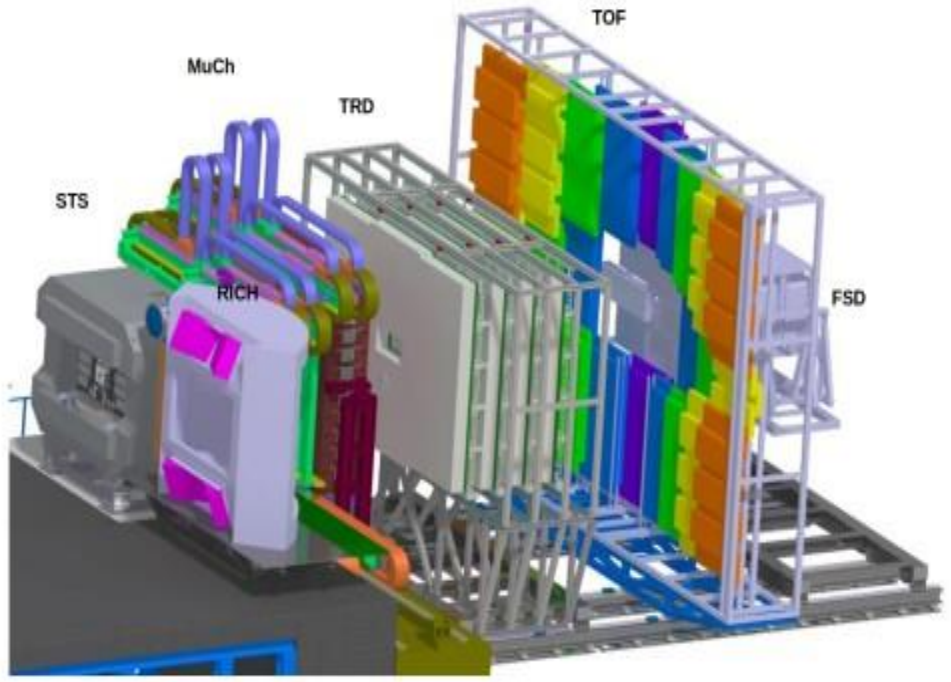


Station 1 & 2: GEM
Station 3 & 4 : RPC
Absorber 1 : Graphite
Absorbers 2,3,4 : Iron



CBM Experiment

- Fixed target heavy-ion experiment
- Designed to explore QCD phase diagram at moderate temperature and high net baryon density
- Measure rare diagnostic probes such as multi-strange hyperons, charmed particles and vector mesons decaying into lepton pairs with unprecedented precision and statistics
- Interaction rates will go up to 10 MHz
- Requires very fast and radiation hard detectors



CBM experimental setup

Dilepton study

-> As the decayed leptons leave the dense and hot fireball without further interactions, they can provide unscathed information about the fireball

-> Dilepton invariant mass can be used to find the temperature and lifetime of the fireball.

-> Di-muon cocktail includes contribution from di-muon ($\mu^+\mu^-$) decay and dalitz decay of ω, η, ρ, ϕ mesons, as well as contributions from thermal radiation of QGP

-> CBM experiment is important as no di-lepton data have been measured in heavy-ion collisions at SIS100 beam energies (2-11 AGeV).